

The University of Chicago

THE SOCIAL HIERARCHY IN RING
DOVES

A DISSERTATION SUBMITTED TO THE
FACULTY OF THE DIVISION OF THE BIO-
LOGICAL SCIENCES IN CANDIDACY FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY

DEPARTMENT OF ZOÖLOGY

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By

MARY A. BENNETT

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THE SOCIAL HIERARCHY IN RING DOVES¹

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INTRODUCTION

Social organization is exhibited in flocks of birds. Investigation in this field was initiated by Schjelderup-Ebbe ('24, '31). In a summary of his studies ('35), he says, "One of the points which the recognition of each individual in the flock of the same species makes it possible to observe is that there exists among birds a definite order of precedence or social distinctions." He states that in over fifty species observed, one bird invariably has precedence over another. This precedence in rank, he asserts, is founded upon despotism. Stimulated by the work of Schjelderup-Ebbe, various studies in this field have been undertaken at the University of Chicago and elsewhere. Masure and Allee ('34a) and Murchison ('35) confirm Schjelderup-Ebbe's observations in the case of the common chicken. Masure and Allee, however, in the case of the common pigeon ('34a) and the shell parakeet ('34b), find that the social organization is based upon a peck-dominance after many conflicts rather than a peck-right established in an initial combat. A number of studies extend the investigation to other birds and to certain other vertebrate groups. Lorenz has studied the social behavior of several birds, among them the jackdaw and the European black crowned night heron ('35), and Noble, Wurm, and Schmidt ('38), that of the American black crowned night heron. Both recognize a social organization. Lorenz finds it in both artificial associations and wild flocks of jackdaws, geese, etc., but not in the colonies of European night herons. Noble, Wurm, and Schmidt find a "hierarchy of dominance" in the American herons, an outgrowth of the struggle for food among nestlings. They conclude that this dominance is completely masked by territorial requirements in older birds except in the case of pairs. Evans ('36) finds a social hierarchy among lizards (*Anolis carolinensis*), as has Urich ('38) in a study of mice.

¹ The author desires to express appreciation to Dr. W. C. Allee for his suggestions and assistance and to Dr. L. V. Domm for his kindness in sexing a group of ring doves.

The present investigation of the social hierarchy in flocks of ring doves was begun for comparative purposes. Do these birds show a type of organization similar to that in flocks of common pigeons? Later the study developed into an attempt at an analysis of certain factors involved in the establishment and maintenance of the hierarchy, such as Allee ('36) has suggested in this connection.

Sexually mature blond ring doves were used, each flock confined in a cage, 25" x 26" x 32". The caged birds were housed in a laboratory of the zoology building of the University of Chicago during the summers of 1935 and 1937, and in the greenhouse of the Whitman Experimental Laboratory in the winter of 1936 and 1937. Two small flocks, under observation during the winter of 1935 and 1936 were kept in a roomy, well-lighted attic of a school building. Adequate water, grit, oyster shell, etc., were supplied at all times. Feeding was done about an hour preceding observation periods. During feeding and immediately following, few contacts between the ring doves were found to occur, hence the allowance for the interval of time. All birds remained in a healthy, active state throughout the series of observation periods except that in the last groups of experiments, wing injuries occurred in two cases.

A difficulty, which the observer encounters in the use of ring doves, is in sex recognition. Whitman ('19) refers to this in numerous instances. External morphological differences are not detectable. Behavior is the chief clue but is complicated by the simulation of the opposite sex on the part of both males and females. Whitman ('19) records the case of two males which paired, one assuming the part of a female through a whole season. He also observes, "The continual isolation of two female doves is usually sufficient to induce their mating with each other. Many of the phenomena of a normal pairing will be exhibited by such unnatural pairs." In the present study observations over two periods were discarded because of the discovery that in each a bird of opposite sex had been present in a supposedly homosexual flock. In one case the appearance of an egg was the first intimation of the presence of a female in a male flock. Isolation of the individual birds and the subsequent appearance of a second egg in the cage of one, identified the female. After this occurrence, until the fall of 1937, only birds who had histories of successful matings were used in the homosexual flocks. In 1937, some additional birds were secured and newly formed groups caged for observation. Where mating histories were unknown, behavior was at first relied upon in segregating sexes. The behavior of certain birds, soon after this separation, indicated some mistaken sex identities. A bird (*G*) in a flock supposed to be composed of females, began to show marked male behavior. On the contrary in a male flock (*D*) grew increasingly submissive. From the time the birds in this case were assembled, this bird was courted by others. To settle identities, Dr. L. V. Domm sexed ten whose mating histories were not fully known. In spite of the contrary evidence from be-

havior, *D* was found to have been correctly identified as a male. On the other hand suspicions regarding *G* were well founded for this bird proved to be a male. All data for the flock containing it were discarded.

An attempt was made to use flocks of uniform size. Complications due to failures in sex recognition, availability of animals, and injuries to wings necessitated some variations. In most of the series, flocks were made up of seven or eight birds. Individuals were banded for permanent identification. Distinguishing marks of nail enamel for use during observations were placed on heads or breasts. These were relatively inconspicuous and, so far as could be determined, were not disturbing to the organization in any flock. In order to reduce any possible affect, the marks were placed on the birds 24 or more hours before observations were begun.

The presence of an observer may have affected the flock organization. However the birds, except for a few days after first securing them, seemed entirely undisturbed so long as no hand or object of any kind was extended above a cage. The observer, while recording contacts, sat quietly on a stool about two feet from the table or shelf which supported the cage. Such activities as filling water containers, cleaning cages, etc., were cared for an hour or more preceding observations. Regularity in time and order of observation periods was maintained with but slight variation. As a rule, the early afternoon hours were used.

THE SOCIAL HIERARCHY

The first series of observations, made in July and August, 1935, were conducted in order to make comparisons of the social organization found in ring doves with that in common pigeons (Masure and Allee, '34). Periods of time corresponding to those in the study of the pigeon were used in the tabulation of the data: 14, 20, 26, and 32 days in the female flock and 12, 18, and 24 days in the male flock. In tables I and II (also III and IV) actual

TABLE I. *Peck-Dominance in a flock of five female ring doves, Summer, 1935*

Doves	14 days	20 days	26 days	32 days
<i>O:WT</i>	1:7	2:7	2:7	4:8
<i>O:RR</i>	0:0	0:0	2:0	2:3
<i>O:P</i>	1:1	1:1	1:1	1:2
<i>O:RT</i>	0:0	0:1	0:1	1:1
<i>WT:RR</i>	0:9	0:11	0:12	0:13
<i>WT:RT</i>	0:2	0:3	0:3	0:7
<i>WT:P</i>	0:1	0:3	0:3	0:5
<i>RT:P</i>	0:0	0:1	0:1	0:1
<i>RT:RR</i>	0:0	0:0	0:0	0:0
<i>P:RR</i>	0:0	0:0	0:0	1:9

Order of Dominance

<i>WT</i> (3)	<i>WT</i> (3)	<i>WT</i> (3)	<i>O</i> (3½)
<i>O</i> (1½)	<i>O</i> (2½)	<i>O</i> (2½)	<i>WT</i> (3)
<i>P</i> (½)	<i>RT</i> (1)	<i>RR, RT</i> (1)	<i>RT</i> (1½)
<i>RR, RT</i> (0)	<i>P</i> (½)	<i>P</i> (½)	<i>P</i> (1)
	<i>RR</i> (0)		<i>RR</i> (0)

TABLE II. *Peck-Dominance in a flock of nine male ring doves, Summer, 1935*

Doves	12 days	18 days	24 days
RD:WW	3:10	4:12	11:17
RD:U	3:19	5:21	7:21
RD:WD	3:11	3:14	3:14
RD:C	0:4	1:6	2:12
RD:RS	0:9	1:12	2:12
RD:RW	2:6	4:6	6:8
RD:RC	2:5	2:7	2:7
RD:V	0:3	1:5	1:8
U:WW	21:37	44:48	45:55
U:V	13:16	14:20	15:20
U:RW	2:5	6:16	11:20
U:RS	8:12	8:16	9:16
U:RC	1:8	1:13	3:17
U:WD	3:7	4:10	4:11
U:C	2:5	2:9	3:10
WW:RC	9:16	11:20	14:23
WW:V	2:12	7:16	7:17
WW:RW	1:4	3:9	8:11
WW:WD	4:6	4:11	6:13
WW:C	0:7	4:10	5:11
V:RW	1:3	3:10	4:14
V:C	0:0	1:2	1:2
V:RS	3:5	4:5	6:6
V:RC	3:1	3:3	3:3
V:WD	2:2	2:2	2:2
RC:WD	6:7	6:8	6:8
RC:RS	0:7	1:9	1:10
RC:C	2:2	3:4	3:4
RW:C	0:5	1:8	2:8
RW:WD	2:2	2:3	2:3
RW:RC	0:0	0:2	0:2
RS:WW	6:9	7:13	8:15
RS:RW	0:2	0:8	0:11
RS:WD	1:2	1:2	2:2
WD:C	1:1	1:1	1:3
C:RS	2:1	2:4	3:4

Order of Dominance

RD (8)	RD (8)	RD (8)
U (7)	U (7)	U (7)
WW (5)	WW (5)	WW (5)
RS (4)	V (4)	V, RC (3½)
RC (3½)	RC (3½)	RW, RS (3)
V (2½)	RW, RS (3)	WD (2)
WD, RW (1½)	C (1½)	C (1)
C (1)	WD (1)	

observations are summarized. The individual doves are represented by letters. Relative dominance at the end of the period of observation is indicated by the arrangement of these letters at the left of the tables. The more dominant individuals are listed to the left in any given pair.

The successive columns give the number of times of observed peck-dominance at the indicated number of days from the beginning of observations. Following the records of observed contacts, the apparent rank in the social hierarchy, referred to as the order of dominance, is tabulated. The birds are ranked according to the number of other birds over which they have dominated, this number being shown in parentheses. (The same method of tabulation has been used in all later tables where the so-called order of dominance is listed.)

In the first observation period (Summer, 1935) of 24 days in a flock of nine males, in only two of the possible contact pairs, did the same bird win all the contacts. In the female flocks contacts were comparatively few. A greater proportion of cases than in the male flock occurred in which one bird was consistently submissive, five out of ten possible contact pairs. The data in the case of the females are very limited and, it may be, that they are inadequate as a basis for conclusions. No complete sex changes in rank in the flock occurred in the males, but there was one in the female flock. The general picture in both flocks is quite similar to that in the corresponding pigeon flocks. Peck-dominance rather than peck-right prevails. The changes in rank are less numerous; on the other hand a larger proportion of contact pairs in both male and female doves are even at summarizing periods than is true of the pigeons.

The observations recorded in tables I and II were made in summer. Due to time limitations a comparison of the data from the doves with premating data only of the pigeons was permitted. To afford a more satisfactory basis for comparison, a second series of observations were made the following winter (tables III and IV).

TABLE III. *Peck-dominance in a flock of five female ring doves, Winter, 1936*

Doves	Pre-mating period			Post-mating period			Grand Total
	14 days	20 days	26 days	16 days	22 days	28 days	
P:RT	16:68	17:72	19:78	6:9	9:11	11:14	30:92
P:WT	2:24	3:31	3:37	8:7	9:8	23:8	26:45
P:RR	4:22	5:22	6:25	4:8	6:13	7:13	13:38
O:P	16:60	18:69	18:73	0:0	1:0	2:1	20:74
O:RR	1:41	1:52	2:58	0:2	3:3	4:12	6:70
O:WT	2:17	2:22	3:23	8:3	9:3	9:5	12:28
RT:O	9:52	21:55	23:57	6:4	8:10	14:18	37:75
RT:RR	2:14	2:16	7:19	2:15	2:22	2:24	9:43
WT:RT	8:3	8:3	9:14	1:112	1:113	1:114	10:128
WT:RR	4:5	5:6	7:11	2:26	2:27	2:51	9:62
Order of dominance							
R, T, P, O (3)	R, T, P, O (3)	P, O (3)	WT (4)	WT (4)	WT (4)	P, O (3)	
WT (1)	WT (1)	RT, WT (2)	P, O (2)	P (3)	P (3)	RT, WT (2)	
RR (0)	RR (0)	RR (0)	RT (1)	RT (2)	RT (2)	RR (0)	
			RR (0)	RR, O (4)	O (1)	RR (0)	

TABLE IV. *Peck-dominance in a flock of five male ring doves, Winter, 1936*

Doves	Pre-mating period			Post-mating period		Grand Total
	12 days	18 days	24 days	16 days	22 days	
RS:V	20:60	33:71	37:85	19:30	29:38	66:123
RS:U	12:47	19:53	22:56	6:49	6:61	28:117
RS:RC	16:41	16:55	23:61	4:10	5:21	28:82
RS:RD	4:44	14:48	21:51	9:13	9:18	30:69
U:RD	35:68	64:83	83:91	11:59	14:77	97:168
U:RC	34:68	48:92	56:99	5:21	9:30	65:129
V:U	34:15	45:24	55:36	38:67	48:85	103:121
V:RC	14:26	18:47	22:58	1:41	2:57	24:115
RD:V	17:3	22:25	25:41	10:4	12:8	37:49
RC:RD	5:62	14:64	19:72	7:12	10:21	29:93
Order of dominance						
RS (4)	RS (4)	RS (4)	RS (4)	RS (4)	RS (4)	
U (3)	U (3)	U (3)	V (3)	V (3)	U, V (2)	
V (2)	RD, V, RC (1)	RD, V, RC (1)	U (2)	U (2)	RD, RC (1)	
RC (1)			RC (1)	RC (1)		
RD (0)			RD (0)	RD (0)		

From January 17 to May, 1936, observations of female and male flocks of five birds each were made. Premating, mating, and postmating records with summarizing periods, corresponding to those in the pigeon flocks, were kept. The females were the same individuals as those in the summer flock; the males, five of the original nine. The pigeon flocks were larger, seven in each, but removal of the doves from the University necessitated a reduction in the number in each lot.

In the data from the 1936 flocks much the same conditions prevail in the premating flocks as in the summer flock. Few changes in rank, one in each group, this time, but fewer "ties" than in summer, are to be noted. Many more contacts were observed in the female flock than in the summer months. Again the picture is one of peck-dominance. Observations of the heterosexual flock, composed of the combined homosexual groups, during a 12-day period, showed attempts at mating on the part of all the birds. During this period *RD* ascended from the lowest to the highest rank, dropping again to the lowest in the post-mating period (table V). It may be that he was stim-

TABLE V. *Comparison of the order of dominance in a mixed flock with that in sex-segregated flocks of ring doves in pre-mating and post-mating flocks, Winter, 1936*

Pre-mating period	Mating period	Post-mating period
Males	Mixed flock	Males
24 days	12 days	22 days
<i>RS</i> (4)	<i>RD</i> (8)	<i>RS</i> (4)
<i>U</i> (3)	<i>RS</i> (7)	<i>V</i> (3)
<i>RD, V, RC</i> (1)	<i>U</i> (6)	<i>U</i> (2)
	<i>V</i> (5½)	<i>RC</i> (1)
	<i>P</i> (4½)	<i>RD</i> (0)
	<i>RC, WT</i> (4)	
	<i>O</i> (3½)	
Females	<i>RT</i> (1)	Females
26 days	<i>RR</i> (½)	28 days
<i>P, O</i> (3)		<i>WT</i> (4)
<i>RT, WT</i> (2)		<i>P</i> (3)
<i>RR</i> (0)		<i>RT</i> (2)
		<i>O</i> (1)
		<i>RR</i> (0)

ulated in some way by contacts with the opposite sex to more decisive activity than in that of the homosexual flock. Except for *RD*'s rise during the period of association with the females, little change occurred in the order of peck-dominance in the male group throughout the entire series. One female (*P*) was able to ascend above *RC* in rank but no other females established dominance over males. As in the female pigeons, one bird (*WT*) appears to be chiefly responsible for the shifts among the females which occur in the three periods. It may be noted that *RR* remained consistently lowest.

In the mixed flock, three pairs of birds mated. Unlike the pigeons, most of the pecking was done by males. The females off the nest were pursued by the males and fewer pecking contacts occurred between the sexes than between males. It is to be observed that *RC* and *RR*, the first pair to mate

and to possess a nesting location, had few contacts with other birds and it was *RC* who was the only male to become subordinate to a female. It appears probable that if more ample nesting space had been provided than was done, other pairs might have become more stable. In that case, the picture might have been more like that of the pigeons', one of couples, each with few contacts with other couples.

While making the observations of the first flocks during the summer of 1935, the question arose as to whether data secured at one period of the day is typical of the remainder of the hours of activity. By way of checking upon this point a second daily period of observations in the male flock, was provided just preceding and during roosting. This period was timed so that it ended just as it became too dark to distinguish markings. It was found that pecking had almost ceased when it became this dark, if not entirely so. Examination of the data (table VI) from this period shows some striking

TABLE VI. *Comparison of daytime and evening periods in a flock of nine male ring doves, Summer, 1935*

<i>Order of peck-dominance, 24 days</i>		
Afternoon	Evening	Total
<i>RD</i> (8)	<i>V</i> (8)	<i>RD</i> (6½)
<i>U</i> (7)	<i>WW, U</i> (6)	<i>V, U</i> (6)
<i>WW</i> (5)	<i>RW</i> (5)	<i>WW</i> (5½)
<i>V, RC</i> (3½)	<i>C</i> (3)	<i>RW</i> (5)
<i>RW, RS</i> (3)	<i>RD, WD</i> (2)	<i>C, RC, WD</i> (2)
<i>WD</i> (2)	<i>RC, RS</i> (1½)	<i>RS</i> (1)
<i>C</i> (1)		

differences from that in the early afternoon. *RD*, *V*, and *C* occupy quite different positions. It appears that the attempt of birds, who during the day remained on the floor or lower perches, to secure positions on the higher perch, affected the relative ranks of certain of the birds. Some birds remained on this perch practically all the time, and, during the day, drove away all others who approached. As dusk descended and the stimulus to roost grew stronger, birds customarily driven off in broad daylight, seemed to become so activated as to win pecking contacts with those on the roost, and consequently, the desired roosting space. These results at least indicate a need for observations over a greater spread of the hours of activity if a complete picture of the social organization of the flock is to be obtained. They also suggest that roosting habits are a complicating factor in connection with the territorialism existing in a flock.

With reference to territorialism, it may be remarked that some degree of this characteristic condition of bird associations, described by Howard ('20), Nice ('37) and many others, was evident in all observed flocks of ring doves. Usually one or more birds in each adopted definite locations in the cage and tended to defend these against all intruders. Usually if the bird showing territorialism left its customary perch or corner, it was compelled to return

by concerted attacks of most of its cage mates. Such behavior is reported by Taylor ('32) and by Masure and Allee ('34a) for pigeons.

In all cases observed, not only those in 1935 and 1936, but in those of the later studies to be reported in this paper, 54 sets of observations of female and male flocks in all (tables VII and VIII), a linear order of ranking is found. It is true that in all but six, at one or more points in the order, two or more birds have an equivalent status. In the males, where a comparatively high percentage of contacts occurs, the linear order is clearer than it is in the female flocks. In only two cases, female flock A, March 31, 1936, and male flock A, March 29, 1936, is there found a perfectly regular series of intervals in this linear order.

TABLE VII. *Order of peck-dominance in flocks of female ring doves during 20 observation periods, 1935-1937*

Date			No. of days	No. of birds in each rank in the social order												Total no. of birds in flock
Yr.	Mo.	Da.		5.5 ²	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5	0	
1935	7	11	32					1	1			1	1		1	5
1936	1	17	26						2		2				1	5
	3	31	28				1		1		1		1		1	5
1937	1	18	16				3		1		2		1			7
	2	17	8			1			1		2		1		1	7
	2	22	16		1		1				2				2	6
	2	27	8				1		3		1		2			7
	3	29	8								4		1		2	7
	3	29	8								2	1	2	1		6
	4	8	8						3		1		1		1	6
	4	9	8				1	1			2		2		1	7
	4	18	8							1	2			3		6
	4	19	8							2	2	2	1			7
	6	17	24		2			1	1	1	1				1	7
	7	13	10						1		4	2				7
	7	23	10		1				2		1		2		1	7
	8	2	5				1				4			2		7
	8	8	10					1	1		2			1	1	7
	8	18	5		1		1			1	1		3	1		7
	8	23	5				1		1		1		2		2	7

² Rank in social order.

In numerous cases especially with females, very few contacts occurred between pairs during observation periods; in some none, and in some, but one or two. It was at first deemed advisable to omit counts of one or two contacts only, since they might not be representative. After continued observations, however, it seemed more unwise to ignore them than to retain them. In some cases these few contacts seemed to be of a very decisive character. This was especially noticeable in female flocks. Such data, even if limited, give a more adequate picture of the social hierarchy than could be obtained in their absence. Since the observer spent several hours daily in the proximity of the various flocks involved, either actively engaged in recording peck-

TABLE VIII. *Order of peck-dominance in flocks of male ring doves during 34 observation periods, 1935-1937*

Date			No. of days	No. of birds in each rank in the social order																Total no. of birds in flock		
Yr.	Mo.	Da.		8 ³	7.5	7	6.5	6	5.5	5	4.5	4	3.5	3	2.5	2	1.5	1	0.5		0	
1935	7	11	24	1		1				1				2	2		1		1		9	
1936	1	17	24										1		1			3			5	
	3	29	22										1		1		1			1	5	
	10	13	24			1			2			1		2			1			1	8	
	11	25	8					2				1	1	2		1	1				8	
	12	3	8			1			1	1		1		1			3				8	
	12	12	8			1			1	2		2				2			1		8	
1937	1	2	8				1		1	1		1	2		1			1			8	
	1	18	16							2	2		1		1			1		1	7	
	2	8	16						2			1		1		1		1		1	7	
	2	16	8						2			1	1		1		1	1			7	
	3	1	8				1						3		1	1				1	7	
	3	4	8					2					2			1		1		1	7	
	3	9	8							1		1	2	2	1						7	
	3	29	8						2		1		2				1			1	7	
	4	7	8							1			1		2	2				1	7	
	4	17	8					1			2	1	1					2			7	
	4	16	8					2				1	1		1				2		7	
	4	16	8									2	1	1		2	1				7	
	4	26	8				1					1		2	1	1				1	7	
	4	26	8				1					1		1				1			7	
	6	17	24			1			1			1				3		2			7	
	6	17	24			1						1			3			2			7	
	7	13	10					1			1	1	1	1		1	1	1			7	
	7	13	10							1		1	1	1	1	1	1	1			7	
	7	23	10					1				1	1	1		2		1			7	
	7	23	10						1			2		1		2		1			7	
	8	2	5								1	1	2			1		2			7	
	8	2	5					1		1					2		1		2		7	
	8	8	10							1	1		1			1	2	1			7	
	8	14	8				1					2		2					1		1	7
	8	18	5							1			1		2				2			7
	8	21	8							1	2				2				1		1	7
8	23	5									2	1	2				1	1			7	

^a Rank in social order.

ing contacts for one or the other of the flocks, or in other phases of this work, it was usually possible to note exceptional cases of contact in any flock and so to determine whether the behavior during observational periods were typical or not.

In general, it may be said that in the series of studies of the summer and winter of 1935 and 1936 in homosexual flocks of ring doves, and in the flocks used in experimental work in 1936 and 1937, the results obtained are similar to those found for the common pigeon and support the conclusions in that case. A definite social organization is indicated and peck-dominance rather than an absolute peck-right is the rule. That is, when two birds peck back and forth, now one retreating and now the other, the one observed to retreat the fewest times is said to have peck-dominance for that pair. It is observed

by Masure and Allee ('34) that pigeons standing high in the social order have more social contacts than those low in the scale. This is in general the situation found in the flocks of doves. In three series of observations of doves (tables II, III, and IV), the three birds in each ranking highest, had higher numbers of contacts than the remaining birds. In each of these cases the two birds lowest in rank had corresponding positions in relative number of contacts. Table I does not show such a relationship but the data in this table are quite meagre and hence may be inadequate for comparison.

COLOR AND CONTOUR AS CUES IN RECOGNITION

It seems probable that certain factors influencing the social hierarchy in bird flocks may be subject to modification. Schjelderup-Ebbe ('35) believes that age, sex, season, health, relative strength, weariness, etc., are among these modifying factors. Age may be involved, yet in this investigation the oldest bird (*RD*) in the original male flock, vacillated in rank. He was high in the social order much of the time but at others he was subordinate to two or more birds of the flock. Sex, in the common usage of the term, was not a factor in these experiments since homosexual flocks were used. Moreover it does not appear that age, sex or the other factors enumerated are sufficient to account for the establishment of the social organization which develops in the flock. When differences in these conditions were eliminated as far as possible in the flocks used, the typical linear flock order still persisted (tables VII and VIII).

A clue to the part which these and other factors play may be found in a study of the means of recognition of one another among flock members. Continued maintenance of a hierarchy implies recognition and memory. Craig ('08) has shown that voice plays a role in recognition in ring doves. This has been confirmed in the present study. Certain calls influenced, not only the flock of which the bird making them was a member, but the other flocks in nearby cages, whether of the same or the opposite sex. A certain synchrony in behavior, seemingly largely dependent upon auditory stimuli, was observed in all the cages in the room. Schjelderup-Ebbe ('35), Allen ('34), Chapman ('35), Noble and Vogt ('35), Noble ('36), Tinbergen ('35) and others have made extended observations of recognition among birds, particularly the phase having to do with sex. Noble and Vogt ('35) after experiments with mounted specimens and with artificially altered plumage characters in the redwinged blackbird and other dimorphic species, conclude that visual cues alone will produce sex responses on the part of the males in the pre-breeding season before females have come into their territories. Noble ('36), states that, "Mature Flickers apparently have learned to recognize the moustache as a badge of maleness." He adds that this badge "will call forth an attack by a territory guarding male even when artificially attached to a female apparently mated with him." Such observations, and experiments with the

cues operative in recognition, seem to have shown, as Verwey ('30) points out, that stimuli, which in birds act as a means of recognition, seem to be auditory and optical.

In the ring doves in many cases no visible color, size or contour differences, either between members of the same or opposite sexes, are to be distinguished by human observers. Moreover, failure of the birds to recognize individuals of the other sex in initial encounters, seems to be evidence that visual cues of color, size, and contour are not operative among the birds themselves. It is because of this that Whitman ('19) refers to the fact that "behavior is of prime importance in sex recognition" and concludes that the behavior of the new comer, after the first encounter, is the only mark by which the courting males are informed about its sex.

If a visual cue, such as any of those found by Noble and Vogt in dimorphic birds, will function, an artificial situation might furnish some clue to it. The question will arise, of course, as to whether the results of experiments in such situations, being abnormal, are of significance. Tinbergen ('35), in his report on the behavior of the red-necked phalarope comments on this point. He says, "These aberrations (attempts to copulate with others, with lifeless things, etc.) of the sexual impulse have been observed especially in the case of captive birds, and it has often been said that they are 'abnormal' and nothing more and that they consequently are worthless for a real understanding of the psychology of birds. . . . I would on the contrary emphasize the importance, which these 'abnormal' cases have especially for psychology, as they show us the working of the inherited instinctive impulses under uncommon circumstances, and reveal in this way characters and features, which remain hidden in normal life." With such a purpose in mind as that to which Tinbergen refers, certain experiments were attempted. The object was to determine, if possible, if recognition in ring doves is in any measure based upon the visual cues of color of plumage and contour differences in individual birds (fig. 1).

In experiments with color, vegetable dyes, eosin, gentian violet and green were used. Breasts and tail feathers were colored. In the experiments with changes in contour, various alterations were made. In some birds, the plumage of the breasts was plucked so as to expose an area about one and one-half inches in diameter. Conversely, in others three cross rows of feathers, turned under side out so as to cause them to curl away from the body, were glued to the tips of breast feathers (fig. 1). The effect was one of puffed breasts with much ruffled plumage. In other birds, the tail feathers were plucked causing the birds to appear stultified and unbalanced (fig. 1). The opposite effect was secured in still others by adding an extra length of tail feathers (fig. 1). This was done by gluing the tail feathers removed from the preceding birds to the tips of the tail feathers growing in the latter. Duco cement was found effective for this purpose. The feathers so attached, remained in place for more than the eight day observation periods in a very

satisfactory manner. The birds in which either dyeing of plumage or contour changes were made, were removed from their cages and so treated at least a half hour before observations began. The alterations were made out of the sight of the flocks involved and the changed birds were then kept in isolation until needed. This permitted drying of colors or setting of glue, as the case might be, and allowed some time for such birds to become accustomed to their own changed plumage.

In 1935, some preliminary observations in which color of plumage was concerned, had been made. While too limited to be of much importance when considered alone, their results may be referred to here in connection with the more extended investigations in the later flocks. A normal, strange blond male; a strange, white male; and finally a familiar blond male and the



FIG. 1. Alterations in the contour of Ring Doves used in recognition experiments.

original normal, strange blond, each of the two latter dyed with picric acid, were introduced, one at a time into the male flock.

With the introduction of the white bird, a violent disturbance was the immediate reaction. For a brief period, the birds flew wildly about in what appeared to be a high degree of alarm. Then *RH* began courting the white dove and the flock returned to its usual behavior. In the evening the white bird was found sitting passively at the end of one perch, *RH* and *I* both courting him. The records of the contacts in both observation periods show the social organization to have been completely disrupted. *RD*, who previously had been consistently at the top of the hierarchy (table II), had but one pecking contact here, and *I*, who had previously remained subordinate to *RD* only, although engaging in 31 contacts with four other birds in the afternoon of this day, became subordinate to three. In the evening, *U*, who had been next to the lowest in rank in the afternoon, again assumed his

usual high rank, becoming dominant in four or five contact pairs. This indicates a temporary disturbance of social order rather than a permanent one.

When the strange blond was introduced, no alarm was apparent. That the birds were aware of his presence was indicated by the fact that they followed him about. Aside from *RW*, none showed a tendency to court him. In the evening, however, much courting was being done, 25 cases of mounting and six of billing occurring in a half hour. The strange bird's plumage was bedraggled and ragged and he appeared to be much the worse for wear when removed the following day. The flock organization was chiefly affected in that few contacts between old members occurred. The attention seemed to be centered on the strange bird. *RD*, who previously was not allowed to alight on the lower perch without setting up a violent series of pecking contacts, could now perch in this location with impunity.

A third experiment was made in the case of *WW*. He was removed from his flock, his plumage was stained with picric acid, and then allowed to dry for some hours. He was returned to his home cage just preceding the afternoon observation period. The remaining birds in the flock seemed more frightened than in the case when the white bird was introduced. They beat violently against the wire of the cage in attempted escape. All fled at *WW*'s approach. The latter behaved in his usual manner, apparently unaware of any irregularity. The period of seemingly intense fright was brief. After five minutes the violence had abated but *WW* was avoided for 16 minutes more. Then courting in the flock began and pecking was resumed. After 21 minutes the flock relationships seemed quite normal. In the evening observation period, fewer contacts than were ordinarily noted occurred but otherwise the flock as a whole seemed quite as usual. In this case, observations continued for a week but no further irregular behavior was noted.

The strange blond used in a preceding experiment and, subsequently completely isolated from the male flock, was stained as *WW* had been and reintroduced into the male flock. Again no alarm at his advent was observable except in a slight degree on the part of *WW*. This was in marked contrast to the effect of the white dove's or *WW*'s introduction. *RW* and *V* immediately began courting the strange bird. Soon *RD* joined them. The stranger withdrew to a perch, remaining there until vicious pecks, sufficient to draw blood, drove him off it. Immediately the other seven began courting him. In the evening and on the following day, the stranger was found in a corner on a perch, extremely submissive and apparently no longer noticed by the group. The flock organization for the observed periods was affected chiefly in a noticeable decrease in pecking contacts.

The results of these four brief experiments, the effect of introducing a strange white, a strange blond, a familiar blond dyed, and reintroducing the strange blond similarly dyed, indicate that a recognition of other birds of the same species, while superficially affected by appearance, must depend upon

other factors. Alarm seemed indicated in the case of the strange white dove, normally different in appearance. A strange bird, but one similar in coloration of plumage, appeared to arouse no alarm. The reaction was that accorded any strange blond ring dove as described by Whitman ('19), one of attempted sex contacts followed by pecking contacts. Even when dyed, the bird was treated similarly, a recognition of it as an intruder seemingly taking precedence over a response to it as an anomaly. The member of the flock artificially colored produced a very different reaction. Here it seems that the unusual appearance resulted in the temporary terrorization of the group. Had it been the reaction to the color, it would seem that a similar one would have occurred in the case of the strange dyed blond. Two explanations can be offered. The birds may have recognized *WW* and so not have reacted to him primarily as an intruder. It may be then that the alarm was due to an unusual change in a familiar individual. On the other hand, since the strange blond was dyed and introduced after a period of contact in the flock with *WW* similarly dyed, it is possible that such coloration on the part of any bird would no longer excite any terror. This idea is supported by the observation that *WW* alone showed evidence of alarm when the dyed strange blond was introduced. Since *WW* had been unable to get a complete view of himself, it may be that he reacted as the whole flock would have done

TABLE IX. *Order in peck-dominance in female flocks of ring doves A and B as affected by artificially colored plumage, 1936 and 1937*

Control	Flock A	
	<i>WT</i> (Green)	<i>RR</i> (Green)
	8 days	
<i>J, RR, RT, P</i> (2)	<i>J</i> (4)	<i>J, RR</i> (2½)
<i>O</i> (1)	<i>RR</i> (3½)	<i>RT, O</i> (2)
<i>H, WT</i> (0)	<i>RT, O</i> (2)	<i>WT, P</i> (1½)
	<i>WT, P</i> (1)	<i>H</i> (1)
	<i>H</i> (½)	
	4 days	
	<i>J</i> (3)	<i>J</i> (3)
	<i>RR</i> (2½)	<i>RR</i> (2)
	<i>WT, P, O</i> (1)	<i>WT, P</i> (1½)
	<i>H</i> (½)	<i>H, O</i> (1)
	<i>RT</i> (0)	<i>RT</i> (0)
Control	Flock B	
	<i>N</i> (Eosin)	<i>Y</i> (Eosin)
	8 days	
<i>N, DD</i> (2)	<i>DD, Z, S</i> (3)	<i>M</i> (2½)
<i>S</i> (1½)	<i>M</i> (2)	<i>N, Z</i> (2)
<i>Y, M</i> (1)	<i>Y</i> (1)	<i>Y, DD, S</i> (½)
<i>Z</i> (½)	<i>N</i> (0)	
	4 days	
	<i>DD, S</i> (2½)	<i>M</i> (2)
	<i>Z</i> (2)	<i>Y, N, Z</i> (1)
	<i>M</i> (1)	<i>DD, S</i> (0)
	<i>Y, N</i> (0)	

had this been the first, rather than the second bird, in the experience of the flock to have an unusual coloration.

In the flocks experimented with in the fall of 1936 and the winter following, where plumage was altered with vegetable dyes or in contour effects, records were kept for eight day periods. Since the preliminary work of 1935 suggested the possibility of unusual disturbances to be anticipated in the initial part of each period, it was decided to make four day summarizations also. This would bring into greater contrast marked temporary aberrations than would be the greater spread of eight days. Initial controls were established by making observations over eight day periods preceding experimental periods. Four groups designated as female and male flocks A and B were used. In tables IX and X are included the names of the dyed birds and the color used in each case. An attempt was made to use for coloring only birds occupying intermediate positions in the social organization of preceding periods. By this means, shifts either upward or downward could be noted. Such selections were not always practicable, however.

TABLE X. *Order in peck-dominance in male flocks of ring doves A and B as affected by artificially colored plumage, 1936 and 1937*

Flock A					
Control	RS (Eosin)	Control	RC (Green)	U (Green)	RD (Gentian)
8 days					
VV, TT (5)	RD (6)	RD (4½)	RD (4½)	RD, U (4)	RD (6)
RS (4)	VV, RC, RS (3½)	RS (3½)	U (3½)	RS (3½)	RS (4)
RC (3½)	TT (2½)	VV, RC (3)	V, RC (2½)	VV (3)	RC (3)
RD (2)	V (2)	TT, U (2½)	VV, RS (2)	TT, RC (2)	VV, TT, V (2)
V (1)	U (0)	V (2)	TT (0)	V (1½)	U (1)
U (½)					
4 days					
	TT (5)		RD (4½)	RD (6)	RS (3½)
	VV (4)		VV, U (4)	RS (3½)	RD (3)
	RC, RS (2½)		RS (3½)	VV (2)	V, RC (2½)
	V (2)		RC (2½)	V, RC (1½)	VV, TT (2)
	RD (1)		V (1½)	U (1)	U (½)
	U (0)		TT (0)	TT (½)	
Flock B					
Control	WG (Eosin)	D (Eosin)	G (Gentian)	Control	TR (Eosin)
8 days					
TR, G (5)	F (5½)	G, D (5)	G (5½)	G (6)	TR (5)
F (4)	S, G (4)	WG (4)	D (4)	TR, WG (4)	WG, G (4½)
WG, D (3)	TR (3½)	TR (3)	TR, F (3)	F, D (3)	F, D (3)
AA (1)	D (3)	F (2)	S (2½)	AA (1)	AA (1)
S (0)	WG, AA (½)	S, AA (0)	WG (2)	S (0)	S (0)
			AA (0)		
4 days					
	G (5½)	D (5)	G (4½)		WG, G (5½)
	D (4½)	G (4)	D (4)		TR, F, D (3)
	F (4)	WG (3)	WG (3)		AA (1)
	S (3)	F (2)	TR, F (2½)		S (0)
	TR (2)	TR (1)	S (½)		
	AA (1)	S, AA (0)	AA (0)		
	WG (0)				

On basis of the data summarized in tables IX and X, alteration in appearance due to coloration of plumage is not shown to materially affect the permanent organization of a flock. In female flock A, *RR*'s position was either in the first or second rank throughout the two preceding and the experimental periods, as well as in the initial four days of the latter. *WT* following coloration did rise from the lowest in the control observation period to an intermediate position in the first four days of the experimental one. She remained one rank above the lowest through the whole eight day period. In female flock B, *N* after dyeing, dropped from highest in the control to lowest in the experimental period and then rose to an intermediate position in the subsequent period. Under similar circumstances *Y* changed one place.

In the male flock A, no change was evident in *RS*'s or *RC*'s positions after dyeing them; a drop of one place only occurred in the four day period with *RD*. In the 16 days preceding coloration, *U* had rather rapidly ascended in rank from lowest to the next highest rank. He dropped to next lowest in the first four days after dyeing, only to rise before the eight days ended to the highest rank. This rise could not have been entirely due to the color, as subsequent to this, *U* made a descent to lowest place in the next eight day period. In male flock B, *WG* made a marked descent in rank following coloration. This was followed by a rapid return to his previous status. This, as in the case of *U*, is not as significant as it first appears, since this bird (*WG*) made another rapid descent and rise 16 days later. *D* made a rather marked rise, falling again later to his former low rank. *TR* ascended one place in rank.

Since changes in rank in the flock are quite common in ring doves, it may be that changes in rank during the experiments in colorations are fully explained on that ground. Nevertheless it is to be noted in all but one of the 12 cases, that some change in rank did occur. In six, 50 per cent, the change in the four day period was greater than in the eight, as contrasted with a greater change in 25 per cent during the eight day period. In two the change was the same for the eight as for the four day period. With the birds not colored, 23.3 per cent showed a greater change in the eight day period than the four day and 26.6 per cent in the four day period than in the eight day. Twenty per cent showed no change. The greater proportion showing changes in rank among the colored than with the uncolored doves and especially in the four day period, suggests that the change in appearance may have had some effect on the social organization, even if a temporary one.

The behavior of the doves on the reintroduction of the dyed individuals was closely observed. Certain stages in recognition were noted to occur, though in varying degrees.

1. Either alarm, with active withdrawal from the proximity of the colored bird or a marked pause in the usual activity without withdrawal was noticeable.

2. The second stage was quite similar to the usual initial reception of a new comer of the same species, an approach on the part of some or all the birds. It differed in that frequently the birds paused as if bewildered at some inexplicable change.

3. Courting of the colored bird by the members of the flock followed the approach. This courting was particularly noticeable as it occurred in the case of several dyed birds which no other birds had previously been observed to court.

The unusual sexual excitement which the coloring seemed to stimulate was the most striking feature of this period. In birds in which dimorphism is not exhibited and in whose plumage no bright or especially deep shades of color are found, it seems strange that artificial changes in color of plumage should so stimulate sexual behavior. When entirely strange birds were introduced, colored or uncolored, there was little or no initial alarm or apparent bewilderment. In such cases, the immediate procedure was that of attack, combined with courting. In most cases such birds were subdued within a few hours and driven into retirement on the end of some perch. With the colored birds, removed only the short time involved in dyeing and drying, the courting differed from that with strange birds in not being accompanied by pecking. This was noticeable with contact pairs, previously in very frequent combat.

It seems reasonable to conclude on basis of the data obtained from observation of flocks in which one member was dyed in a very conspicuous manner, that the social organization is temporarily affected in some degree by the reactions to the new situation. This change in organization appears to be of short duration but to be marked while it lasts. Therefore, while color may be a factor in recognition, it seems to be very limited in effects on continued flock organization.

A factor entering into visual recognition of individuals by man is that of contour. Several experiments were devised to determine, if possible, whether ring doves show such recognition. If so, in how far is social organization affected by it? Seven experiments were performed, two with females, five with males. (The results of three other experiments with females were discarded when a male was found to be a member of the flock.)

Few marked changes in hierarchy (tables XI and XII) were observed during this series of contour alterations. As with those with color, the changes which were noted may have been the result of normal fluctuations in the social order within flocks. No violent disturbances immediately followed the entrance of any altered bird. Hence less temporary disorganization occurred in the four day period in contour changes than in those with color. The only marked change in rank was in *V*, the male to whom breast plumage was added. There was a descent here from highest to lowest rank in the four day period. *V*'s course in preceding periods was an erratic one, hence

TABLE XI. *Order in peck-dominance in female flock A of ring doves as affected by artificially altered contour, 1937*

Control	WT (Plucked tail)	J (Added tail)
	8 days	
J, RT (4)	RT (4½)	RR (4)
RR, P, O (3)	J (3)	RT, P, O (3)
H, WT (1)	WT, P (2)	J (2)
	H (1)	H, WT (1)
	O (½)	
	RR (0)	
	4 days	
	J (3)	J, RT, O (2)
	P (2)	H, WT, P (1)
	H, RT, WT, O (1)	RR (0)
	RR (0)	

TABLE XII. *Order in peck-dominance in male flocks A and B of ring doves as affected by artificially altered contour, 1936 and 1937*

Flock A					
Control	V (Plucked tail)	RS (Extended tail)	RD (Plucked breast)	Control	V (Added breast plumage)
	8 days				
TT (7)	VV, TT (5½)	TT (7)	TT (5½)	V (5)	VV, TT (5)
RS (6)	RD (4)	RC (5)	VV, RS (5)	VV, TT, RC (4)	RS (4)
RD (5)	U (3½)	RS (4½)	V, RC (4)	RS (3)	RC (3½)
VV (3½)	V, RS (3)	VV (4)	RD, U (2)	RD (1)	RD (2)
V (3)	D (2)	RD (3)	D (½)	U (0)	V (1)
U (2)	RC (1½)	U, V, D (1½)			U (½)
RC (1½)					
D (0)					
	4 days				
	RD, VV, TT (5½)	TT (5½)	TT (7)		VV (5)
	U, V, RS (4)	RD (4½)	RS (5)		TT (4)
	D (1)	VV (3½)	RC (4½)		RS (3)
	RC (0)	D (2½)	VV (4)		RD, RC (2)
		RC, U, RS (2)	V (3)		U, V (1)
		V (0)	RD, U (2)		
			D (½)		
Flock B					
Control	G (Added breast plumage)				
	8 days				
G, F (5)			TR, G (5½)		
TR (4)			F, D (3½)		
AA (3)			WG (2)		
WG (1½)			AA (1)		
D (1)			S (0)		
S (½)					
	4 days				
			TR, G (5)		
			F (3)		
			WG, D (2)		
			S (1)		
			AA (0)		

it is not unreasonable to explain his abrupt change here as one characteristic for him under any circumstances.

The behavior in the flocks undergoing color alterations was found to be temporarily affected. No such disturbance was observable in connection

with contour changes. In *V*'s case only did a flock give evidence of any immediate recognition of alteration. No alarm was evinced but the birds did gather about *V* and look at him about ten minutes. Then in a marked degree, they began courting him. As was to be expected, the altered birds, themselves, were much disturbed by losses or additions of plumage, particularly the latter. That flaunting added parts would attract attention and prove disquieting to the others seemed probable. It was not found, however, that this was noticed by other birds, unless momentarily in a few cases.

On basis of the observations and the data obtained regarding contour, we may conclude that contour is of very minor importance in recognition and in the establishment of the social hierarchy. Evidently the members of a flock depend upon other factors for recognition. Moreover, they seem not to be confused in identities, at least to any marked degree, by such alterations as loss or addition of tail feathers and breast plumage.

Experiments with alteration of color and contour have not satisfactorily solved the problem of recognition in flocks of ring doves. These birds evidently notice changes produced by adding color. This is to be expected from studies made of their powers of vision. These show them to have much the same sensitiveness to wave length as does man and to have a similar trichromatic mechanism and "line discrimination curve" (Hamilton and Coleman, '33). The initial reactions to the colors noted, which seem to be fright and perplexity, appear to be those evoked by an abnormal situation. It seems that only when some factor or factors, concerned with behavior, become apparent to the bird, does recognition occur. In the case of contour, the changes seem ones of small moment in a ring dove's life. It may be for example, that an abbreviated tail in a dove is too common an occurrence to excite any reaction. Young birds' tails are abbreviated, and older birds frequently lose tail feathers. It is difficult to explain why the extenuated tail, and the display made by its unfortunate possessor, did not attract greater attention. If the explanation of recognition is to be satisfactorily made, it will have to be on some other basis than that of visual cues of color and contour as used in the present study.

DISCUSSION

There seems little argument as to the existence of a definite social hierarchy in ring doves. The order is quite similar to that observed in the common pigeon. This is to be expected in birds as closely related as these species of the Columbidae. Recognition between the individuals of a ring dove flock is evident. The basis of this is seemingly some more subtle factor or factors than gross color or contour peculiarities. The evidence is in favor of an explanation on the basis of recognition, visual and auditory, having primarily to do with behavior. Investigation having to do with modification of innate factors in behavior seems more promising as a means of explaining

the social relationship of the flock members than that with changes in gross appearance.

The tabulations used in this study are based on 10,915 pecking contacts during 273 hours. In each of these one or the other of the birds in the pair involved was successful. Many "non-decision" contacts observed are not included. The average per hour of the tabulated contacts was 39.9 for all birds. In female flocks these contacts averaged 20.1 per hour, in the male flocks, 53.8 per hour. Frequently the combats were vicious; in a few blood was drawn. The observations reported in this study were supplemented and confirmed by ones in a larger outdoor pen, by those of other caged groups of varying numbers, young and old, heterosexual and homosexual, and by those of paired birds. They tend to discredit the expression "gentle as a dove" and to raise a question as to the suitability of the dove as an emblem of peace.

CONCLUSIONS

1. A peck-dominance, rather than a peck-right, determines the social organization of caged flocks of ring doves.

2. Recognition of change in appearance of ring doves, due to artificial coloration of plumage, is evident in a tendency toward a temporary disturbance of the social order, accompanied by certain peculiar aberrations in general behavior.

3. Recognition of change in appearance in ring doves, due to artificial alteration in contour, is evident in a very limited degree. The social organization shows no unusual modification.

4. The evidence indicates that differences in color or contour are not factors of any considerable importance in recognition of individuals in flocks of ring doves.

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THE SOCIAL HIERARCHY IN RING DOVES. II. THE EFFECT
OF TREATMENT WITH TESTOSTERONE PROPIONATE

THE SOCIAL HIERARCHY IN RING DOVES. II. THE EFFECT OF TREATMENT WITH TESTOSTERONE PROPIONATE¹

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INTRODUCTION

Social organization has been described in flocks of many species of birds both wild and caged. Schjelderup-Ebbe ('24, '31) reported in more than fifty species a type of hierarchy which he designated as a "peck-order." Subsequent investigation by others has confirmed his observations with relation to the domestic chicken (Masure and Allee, '34a; Murchison, '35). In the case of pigeons and shell parrakeets, Masure and Allee ('34b) reported a social order based upon "peck-dominance" rather than peck-right, that is, upon a dominance established after many conflicts rather than upon an initial combat. Shoemaker ('39a) and Bennett ('39), in flocks of canaries and of ring doves respectively, likewise found peck-dominance to be characteristic of the social organization in caged flocks of these birds. Others who have observed hierarchies in bird flocks, based upon dominance in some form, are Lorenz ('35) in jackdaws, geese, and certain other birds, both in wild and artificial associations, and Noble, Wurm, and Schmidt ('38) in American black crowned night herons.

The question arises as to what factors underly the social organization in a flock of birds. Schjelderup-Ebbe ('35) directed attention to a number of conditions which he believed to be of some importance in this matter. Among them were health, season, sex, age, relative strength and fatigue. Certain of these same conditions have been recognized by other investigators. Allee, referring to the do-

mestic hen, says, "Sickness limits the social activity of a bird and may result in a loss of social position" (Allee, Collias, and Lutherman, '39). In wild flocks, season operates in relation to the breeding cycle. In that sense season is probably of significance in flock control. Shoemaker ('39a) found in caged canaries that "position in the social hierarchy fluctuates with breeding activity." Age has been reported as affecting the social status of chickens when immature and mature individuals are both present (Allee, '38). In canaries, Shoemaker failed to find a correlation between age and social position. Homosexual flocks of ring doves, sexually mature, and healthy according to ordinary criteria, have been observed in this and previous investigations (Bennett, '39) at all seasons of the year. In these flocks, it appeared that the elimination of differences in such conditions as health, sex, and age, at least in the ordinary usage of these terms, did not greatly modify the flock order.

Some degree of recognition of individuals is implied in any social organization. By an analysis of the factors involved, a better understanding of that organization should be possible. The senses of hearing and sight are well developed in birds. Certain studies of these in relation to recognition have been made. Craig ('08) found in doves and pigeons a marked effect of "voice" upon flock activity. Much of this was of a transitory nature. Gross changes in appearance, so far as the effect of altered coloration of plumage and modifications of contour were concerned, produced negligible results (Bennett, '39). Flock organization was only temporarily disturbed. The doves seem to be aware of changed appearances but to base recognition of individuals on some more innate factor or factors. Human

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observers have considerable difficulty in distinguishing sexes in ring doves because of the lack of external, morphological differences. The birds themselves seem unable to readily determine the sex of new arrivals until initial responses to approaches have been made. Whitman ('19) said, "The behavior is the only guide they have in selecting a mate of the right sex." It is probable in flock organization, as in sex, that recognition is based upon behavior characteristics. With modification of behavior, changes in responses are to be expected, and more or less alteration of relationships in the flock.

Some experimental work in the modification of the social order in bird flocks, as well as of other conditions, has been done. It has been based upon the idea that the degree of pugnacity and aggressiveness, which enables a bird to maintain its social position, is dependent, at least in part, upon the relative amount of "maleness" possessed by it. Whitman reported a frequent occurrence of fighting in homosexual ring dove pairs. Riddle (Whitman, '19) commented upon this observation by postulating that such combats in either sex were probably due to varying degrees of maleness. More recently Allee ('36) suggested that sex hormones might "alter experimentally the physiological state of selected birds of known status in the social group" and, incidentally, the social order as well. It has been shown that aggressiveness in female birds can be enhanced by the injection of male hormone. Allee and co-workers (Allee and Collias, '38; Allee, Collias and Lutherman, '39) observed such changes in flocks of hens, as well as a resultant modification of social status, after injection of testosterone propionate. The work of Shoemaker ('39b) with canaries confirms their results. Noble and Wurm ('38) in black crowned night herons, Hamilton and Golden ('39) with hens, and Leonard ('39) with canaries, have verified the idea that testosterone

propionate produces behavior in female birds of a definite male pattern.

The present investigation has had as one of its purposes an attempt to discover whether the injection of testosterone propionate in ring doves, birds possessing a well defined peck-dominant type of organization, would parallel the developments in hens and other birds under similar treatment. In the second place, if such parallelism resulted, it was planned to repeat the procedure used in as nearly an identical manner as might be practicable. The purpose of such repetition was that of securing further evidence necessary to valid conclusions in birds with a flexible social organization. A single series of results, while apparently confirming those obtained in chickens where the peck-order prevails, might in birds with a peck-dominant organization, as is the case with doves, be a matter of chance. Repetition of the experimental procedure would assist in clearing the picture, either confirming or raising a question as to the conclusions to be drawn. A third matter for investigation has been the question as to whether, with injection of testosterone propionate, there might appear a change from the peck-dominant to the peck-right form of organization in the ring dove flocks concerned.

Both male and female flocks were used. If, as Riddle suggested, and as subsequent investigations have seemed to show, the degree of maleness in either sex is an important factor in aggressiveness, modification by injection of male hormone should have effects in male as well as female flocks.

METHODS AND MATERIALS

The procedure in this investigation, so far as the general care of the birds was concerned, varied little from that in the preceding one (Bennett, '39). Caged flocks, seven birds in each, were used. One flock was of females and two of males. Male flock *B* was composed of doves raised by the investigator, and the

offspring of two related pairs. The ages in this flock varied but four months. The other birds were obtained from commercial sources. All in the three flocks were sexually mature when used. Individuals were permanently identified by metal bands but marked with colors for ready recognition. The flocks received daily care with regard to food, water and cleanliness. In the summer they were housed within Whitman Laboratory, in the fall months in the greenhouse of the same building.

Recorded observations, an hour each per flock, were made daily. (At times of lessened activity, these could be made simultaneously for more than one flock; much of the time each required separate records.) In addition, particularly during the summer, the flocks were under observation much of the remainder of the time during daylight hours. By working quietly in the neighborhood of the birds, any unusual conditions could be checked.

The three flocks, with the same individuals in each, were maintained throughout the investigation. The reported observations began June 27, 1939, but an earlier series made in April were available for comparison. The summer observations, series I, ended September 12 after seventy-eight days of continuous records. Series II began October 3, and ended November 21, fifty days in all. The pre-

injection or control, the injection, and the post-injection periods within each series, are shown in table I. The pre-injection or control period of eight days was arbitrarily fixed at this length since results in all previous studies of ring doves (Bennett, '39) had seemed to indicate as accurate a picture of any given flock organization, in an undisturbed condition, in this period as in those of greater length. The pre-injection period of series II proved of double use, both as a check upon the post-injection conditions for series I and as a control for series II. In the injection period of series I, one bird in each flock was treated continuously for forty-eight days. Beginning on the thirty-fifth day of these injections, an additional bird each in male flock A and in the female flock were treated for twenty-four days. While twenty-one days' post-injections in the first three cases were possible, only ten days could be used for the latter two. In series II, three of the originally treated birds, one from each flock, were again the experimental subjects. The periods were similar for all. The control period was eight days as in series I. The following two intervals were somewhat curtailed in length.

The experimental birds were selected, not only upon the basis of their ranks and behavior in the control period, but also

TABLE I. *Calendar of observations in flocks of ring doves, 1939*

Doves		Series I			Series II			Total days
Name of treated bird	Flock	Pre-injection	Injection	Post-injection	Pre-injection	Injection	Post-injection	
		8 da.	48 da.	21 da.	8 da.	24 da.	17 da.	
X	A ♂	27.vi-5.vii	16.vii-22.viii	23.viii-12.ix	—	—	—	77
EB	B ♂	27.vi-5.vii	16.vii-22.viii	23.viii-12.ix	3.x-10.x	12.x-4.xi	5.xi-21.xi	126
D	♀	27.vi-5.vii	16.vii-22.viii	23.viii-12.ix	3.x-10.x	12.x-4.xi	5.xi-21.xi	126
		8 da.	24 da.	10 da.				
RW	A ♂	1.viii-8.viii	9.viii-2.ix	3.ix-12.ix	3.x-10.x	12.x-4.xi	5.xi-21.xi	126
RH	♀	1.viii-8.viii	9.viii-2.ix	3.ix-12.ix	—	—	—	77

as a result of their performances previous to the reported observations. These doves were, so far as could be determined, the least aggressive individuals in their respective flocks, and the birds most consistently low in rank. It was important to consider consistency in status since certain ring doves, in almost all caged groups observed, have shown an erratic type of flock relationship. *EW* in male flock *B* in the present investigation is an example of this sort. If such a bird, with a tendency to change readily in flock position, were to be used experimentally, it is clear that it would be difficult to interpret results in his case.

During the experimental periods, testosterone propionate was injected daily, intramuscularly, in the subjects. All other

birds received similar treatment with sesame oil. The original daily dosage used was 0.25 milligrams, but this amount was doubled in all males after twenty-four days. Since the apparent female response remained practically maximum, once it reached this peak, it was deemed unnecessary to increase the amount of hormone used. A change in the males, since such a maximum response was not indicated, was made in the attempt to learn whether insufficient dosage was responsible.

MODIFICATION OF THE SOCIAL HIERARCHY FOLLOWING INJECTION OF TESTOSTERONE PROPIONATE

The history of each flock and of each treated bird in series I is discussed sep-

TABLE II. *Order in peck-dominance in the female flock of ring doves as modified by injection of bird D with male hormone. Double vertical lines enclose the injection periods*

Series I							
Doves	8 da.	0.25 mgm.					21 da.
		8 da.	8 da.	16 da.	16 da.	Total	
D:C	2:1	0:1	0:1	9:2	1:2	10:6	11:6
D:RH	0:0	0:1	2:0	0:5	0:1	2:7	7:4
D:T	0:0	0:2	0:6	0:28	0:21	0:57	1:5
D:E	5:0	4:0	4:3	0:27	0:39	8:69	0:17
D:G	0:0	3:12	0:22	1:89	1:71	5:194	0:28
D:S	0:0	0:0	0:1	0:13	0:3	0:17	0:6
C:RH	0:0	0:3	0:0	0:2	4:1	4:6	16:4
C:T	1:0	4:1	7:0	7:2	9:11	27:14	11:2
C:E	0:1	0:1	0:7	1:16	0:9	1:33	1:20
C:G	0:8	0:2	0:11	0:19	0:6	0:38	0:34
C:S	2:1	2:0	5:1	0:23	1:7	8:31	1:23
RH:T	0:0	0:2	0:11	0:3	0:53	0:69	0:40
RH:E	0:0	0:1	1:0	2:0	6:13	9:14	0:10
RH:G	0:1	4:0	4:1	9:0	33:1	50:2	4:2
RH:S	0:0	0:0	2:0	0:0	2:9	4:9	0:9
T:E	2:2	0:3	0:3	8:6	0:5	8:17	2:8
T:G	1:3	1:2	1:0	7:3	21:1	30:6	9:11
T:S	0:1	0:0	0:1	2:0	0:3	2:4	0:10
E:G	0:0	4:3	0:4	0:4	2:8	6:19	2:20
E:S	0:0	1:0	1:1	0:8	2:5	4:14	0:7
G:S	1:0	2:0	1:0	7:1	2:0	12:1	0:10
Total	14:18					190:627	65:276
Rank in Flock	T(3,5) C(3) S(2) E(1,5) RH(1) G,D(0)	D(4) C,T,S(3) G,RH(2) E(1)	D(4) E,S(3,5) T(3) G,C,RH(2)	D,C(5) E(4) G,S(2) RH,T(1)	D(6) C(4) E,RH(3) G,T(2) S(1)	D,C(5) RH,T(3) G,E(2) S(1)	RH(5) D,C,T(4) G,E(2) S(0)

TABLE II (Continued)

Series II

Doves	8 da.	0.25 mgm.			17 da.
		8 da.	16 da.	Total	
D:C	7:0	3:1	7:13	10:14	8:8
D:RH	5:0	6:5	3:9	9:14	1:14
D:T	1:0	0:5	2:23	2:28	0:24
D:E	0:3	0:2	1:46	1:48	0:17
D:G	0:6	1:19	0:62	1:81	0:19
D:S	0:0	0:8	4:37	4:45	0:24
C:RH	3:1	0:3	2:6	2:9	6:2
C:T	1:0	0:0	7:2	7:2	8:5
C:E	0:10	1:1	3:26	4:27	0:27
C:G	1:22	0:4	1:11	1:15	1:23
C:S	0:14	0:8	0:23	0:31	0:26
RH:T	0:0	0:1	0:6	0:7	0:6
RH:E	0:0	0:0	3:1	3:1	1:1
RH:G	0:0	0:0	6:2	6:2	7:0
RH:S	0:0	1:1	4:2	5:3	0:0
T:E	1:0	0:0	2:1	2:1	2:3
T:G	2:1	1:0	26:0	27:0	21:0
T:S	0:1	0:2	4:7	4:9	2:3
E:G	5:5	3:2	12:3	15:5	19:4
E:S	0:7	0:2	2:11	2:13	7:6
G:S	2:20	0:8	4:27	4:35	1:29
Total	28:90			109:490	84:241
Rank	C(4)	C(4.5)	D(6)	D(6)	D(5.5)
in	T(3)	D(4)	G,C(4)	G,C(4)	G(4)
Flock	G,E(2.5)	G(3)	E(3)	E(3)	C(3.5)
	D,RH(2)	RH(2.5)	T(2)	T(2)	T(3)
	S(0)	E(1.5)	RH,S(1)	RH,S(1)	RH(2.5)
		T(1)			S(1)
		S(.5)			E(.5)

arately since the condition in each varied somewhat. In the tables accompanying each record, individual birds are represented by letters. The successive columns of figures give the number of times of observed peck-dominance in the indicated contact pairs for the period shown. In table II, for example, *D*'s contacts with *C* in the pre-injection period are recorded as 2:1. *D* won in one encounter as contrasted with two winning contacts on *C*'s part. For the total injection period of forty-eight days, the comparative winning contacts are listed as 10:6, that is, six in *D*'s case, and ten in *C*'s case. *C* is said to be peck-dominant in both periods. The rank in the flock, shown in the latter part of each table, is determined according to the number of other birds over which

any one bird has dominated. This number is shown in parentheses.

Series I. Female Flock.—The original experimental female, *D*, was before injection, in the lowest rank (table II). She was an extremely quiet, passive individual, making almost no contacts and those, in large part, losing ones. On the sixth day following injection, *D* had risen a stage in rank, having subjugated one bird. The following day she was discovered in top rank but sharing it with *C* and *T*. On the eighth day, *D* had her first observed pecking contact with *C* following injection, and won it in a decisive manner. This elevated her to an isolated state in first place in the flock. So long as injections continued, *D* remained in first rank, but shared it at times with *C*.

(Once, too, for three days, the tenth to the twelfth, *S* and *T* were in the same position.) Five days after injections ceased, *D* became secondary to *C*. On the eighth day and for the thirteen remaining post-injection days *D* became subservient to *RH*, but through this period, shared second place with *C* and *T*. *RH* was still being injected for eleven days of this period, a fact which probably accounts for her ascendancy over *D*. The data for the twenty-one day post-injection period showed no marked change in *D*'s status, such as occurred in the injection period. The chief modification, too, is involved with the treatment of the second flock member. Less noticeable shifts in relationship were nevertheless in process. An examination of the last five days' data showed *D* in third rank, if those days alone were considered. Fifty days after cessation of treatment, at the end of the control period in series II, *D* was found in fourth rank in advance of one bird only.

D's behavior changes were quite striking. From an apparently voiceless and a very submissive bird, she began soon after injections started, a progressively cumulative series of developments which resembled quite closely the steps in typical male dove courting ceremonies (table III). The first evidence of this change observed was somewhat startling in nature. The female flock as a whole had been an unusually quiet one. In the scattered cases where vocalization occurred it was brief in nature and weak in tone. When on the fifth day of *D*'s injection, a strong, clear "bowing-coo" issued from the corner occupied by the cage of the females, it was difficult to attribute this call to one of the birds there. Repetition was convincing, and *D* was found to be the vocalist. Such behavior became frequent with her in the weeks following. When copulation was attempted by this same bird on the thirty-fourth day, it was the culmination of a succession of appearances of various stages in the male courting pattern. Oc-

TABLE III. *Initial appearance in female ring doves during injection by male hormone of characteristic types of male courting behavior*

Male courting behavior	Days following first injection		
	D		RH
	Series I	Series II	Series I
1. Bowing and cooing to second individual	5	1	2
2. Approaching from sides as if to mount	7	5	—
3. Following courted individual from place to place	15	12	—
4. Billing	16	5	15
5. Courting arousing reciprocal excitement	17	14	—
6. Courting followed by "Flat-tening" on part of other bird	20	—	3
7. Pecking preceding posturing	22	—	—
8. Mounting courted bird	34	—	—
9. Mounting, succeeded by attempted copulation	34	16	—

curing initially in each case at intervals of several days, each had been a part of a progressive sequence. It may be noted that it required a few days over a month before the summation of all stages appeared in a complete courting pattern climaxed by sexual contact. No further "copulation" on *D*'s part was observed although she was watched closely for considerable periods each day. She was seen on two further occasions to mount other birds but failed to attempt copulation. A different type of observation gives added evidence of a change in a male direction. *D* was temporarily introduced into the male flocks and into a mixed flock, both during the control period and in the later part of the injection period. Before injection *D* was courted by the males in the various cages and was herself very passive and irresponsive. After several weeks of injection, she usually took the initiative in encounters, occasionally fighting the higher ranking males viciously. In the mixed flock, she courted other females but fought the males. After cessation of injections *D* gradually

TABLE IV. Order in peck-dominance in the female flock of ring doves as modified by injection of bird RH with male hormone. Double vertical lines enclose the injection period. The last column refers to an eight day period of observations ending 39 days after injections ceased

Doves	8 da.	0.25 mgm.			10 da.	8 da.
		8 da.	16 da.	Total		
RH:D	3:0	0:0	2:3	2:3	3:3	0:5
RH:T	0:5	0:26	0:36	0:62	0:13	0:0
RH:C	0:0	1:2	1:11	2:13	3:3	1:3
RH:E	6:0	2:8	0:9	2:17	0:5	0:0
RH:G	6:0	27:0	5:2	32:2	0:1	0:0
RH:S	0:0	2:4	0:9	2:13	0:4	0:0
D:T	0:36	0:6	0:10	0:16	1:0	1:0
D:C	6:2	0:0	6:8	6:8	6:0	7:0
D:E	0:21	0:16	0:21	0:37	0:0	0:3
D:G	0:50	1:38	0:40	1:78	0:7	0:6
D:S	0:10	0:0	0:6	0:6	0:3	0:0
T:C	4:6	8:6	3:10	11:16	0:2	0:1
T:E	4:7	0:2	1:5	1:7	1:4	1:0
T:G	8:2	15:0	13:4	28:4	0:7	2:1
T:S	2:0	0:0	0:10	0:10	0:3	0:1
C:E	0:6	0:6	1:13	1:19	0:8	0:10
C:G	0:12	0:4	0:16	0:20	0:18	1:22
C:S	0:16	1:3	0:12	1:15	1:14	0:14
E:G	0:8	2:2	0:6	2:8	2:6	5:5
E:S	0:6	2:3	0:5	2:8	0:4	0:7
G:S	7:0	2:0	0:6	2:6	0:4	2:20
Total	46:187			95:368	17:109	20:98
Rank in Flock	D(5) C(4) E(3) G,T(2) RH,S(1)	C,RH(4) D(3) G(2.5) E(1.5) T,S(1)	D,RH(5) G,C,T(3) E(2) S(0)	D,RH(5) G,C,T(3) E(2) S(0)	RH,T(5) C(4.5) D(2.5) E(2) G(1) S(0)	C(4) T(3) G,E(2.5) D,RH(2) S(0)

became less aggressive and active. By the tenth day she was found most of the time at the end of a perch. (Developments during the second series of injections will be considered in a later section of the paper.)

The second experimental female, RH, until injections began, was, like D, consistently low in rank. Unlike D, she was a rather active individual. On one occasion she had been observed to bow and coo to another female. Her pecking contacts, in comparable pre-injection periods, were almost as rare as D's. In this period, RH was in lowest rank, together with S (table IV). Here she remained until the sixth day of injection. On that day she had assumed dominance over four members of the flock and was in second rank with D. (D's ranking here

is based on the days of the period concerned in observations of RH's reactions.) On the following day, RH shared first rank with C. Thereafter she was either in first or second place, in company with or dominating D, and always dominating the others of the flock. RH continued with T in first rank, to the end of the observed post-injection period. Thirty-nine days later, at the close of the control period for series II, RH was once more in the lower ranks. Apparently, as in D's case, she had resumed the pre-injection status.

RH's behavior failed to follow the clear-cut progression toward typical male conduct which characterized D's. It may be that the simultaneous injection of the two, one in the later days, the other in the initial stages of the changes following

TABLE V. Order in peck-dominance in male flock of ring doves *A* as modified by injection of bird *X* with male hormone. Double vertical lines enclose the injection period. The last column refers to an eight day period of observations ending fifty days after injections ceased

Doves	8 da.	0.25 mgm.		0.5 mgm.		Total	21 da.	8 da.
		8 da.	16 da.	8 da.	16 da.			
X:TD	8:3	3:2	3:0	2:0	4:0	12:2	7:0	4:0
X:W	6:2	1:0	11:8	9:0	12:1	33:9	7:0	4:1
X:Z	10:12	2:4	7:11	2:8	4:4	15:27	21:0	15:6
X:FD	26:8	4:8	11:20	14:14	14:5	43:47	4:0	7:6
X:RW	5:5	3:9	0:8	0:0	2:3	5:20	33:2	0:1
X:TB	1:3	1:14	7:12	2:8	7:12	17:46	3:0	0:0
TD:W	13:3	10:8	14:16	1:6	19:9	44:39	8:9	35:5
TD:Z	11:15	11:4	4:11	0:0	6:10	21:25	37:16	9:2
TD:FD	5:64	5:7	3:20	0:6	3:16	11:49	3:10	5:31
TD:RW	11:20	6:17	3:16	1:7	8:8	18:48	41:17	0:32
TD:TB	5:27	7:15	5:19	0:4	1:8	13:46	0:18	0:14
W:Z	2:12	5:14	8:37	6:19	8:28	27:98	23:7	1:11
W:FD	25:15	15:29	15:44	25:32	29:57	84:162	8:1	1:44
W:RW	0:16	7:35	32:31	11:28	24:49	74:143	33:13	0:20
W:TB	7:8	3:29	7:31	0:9	5:47	15:116	0:4	0:14
Z:FD	12:19	3:5	23:31	7:13	16:23	49:72	13:33	6:21
Z:RW	7:8	12:12	30:51	14:14	31:19	87:96	39:20	0:22
Z:TB	4:9	2:7	8:31	4:15	4:16	18:69	0:38	0:7
FD:RW	7:4	1:4	6:5	1:10	10:17	18:36	29:12	1:9
FD:TB	11:24	3:5	22:10	23:2	19:4	67:21	1:22	0:15
RW:TB	6:14	4:5	25:15	21:8	25:13	75:41	0:51	2:1
Total	182:291					746:1212	310:273	90:262
Rank in Flock	TD,W(5) Z,FD(3) X,RW(2.5) W(0)	W(6) X,TD(4) Z(3.5) FD(2.5) RW(1.5) TB(0)	TD(6) X,W(4) Z(3) TB,RW(2) FD(0)	TD,W(5) X,Z(2.5) TB(2) FD(1.5) RW(.5)	W(6) TD(4.5) X,Z(2.5) X,TB(2) RW(1.5)	W(6) TD(5) X(4) Z(3) TB(2) FD(1) RW(0)	Z,RW(5) TD,W(4) FD(2) X,TB,W(0)	W(6) Z(5) TD(4) FD(3) X,TB(1) RW(0)

treatment with testosterone propionate, complicated the picture. It was at this point that *D* failed to continue the newly developed copulation practice. Then, too, *RH*, as previously noted, had been observed in a preliminary courtship act before being treated. So far as she was watched, *RH* did not attempt the sexual act. She was noted in an attempt to mount on two occasions. After cessation of injections *RH* rapidly became as passive as *D*. By the fifth day she was usually on the perch at *D*'s side. In contrast, the other flock members were quite as active as during the injection periods, changing locations, occasionally pecking one another, and infrequently courting.

Series I. Male Flocks.—The bird, *X*, selected from male flock *A* for experimental treatment, was one of the less active birds and in the next lowest rank in the pre-injection period (table V). During that eight-day period he had been observed to win in thirty-seven encounters. After five injections *X* was found with *TD* in second rank and maintained

this position to the twentieth day. In the first eight days of injection, *X* had thirty-three encounters. In the preceding period he had had a few more winning contacts but dominated in the total pair contacts in two cases only, those with *Z* and *TB*; in this second period, in four, those with *Z*, *FD*, *RW*, and *TB*. The total individual decisive contacts on the part of all birds were ninety-seven in the pre-injection period; forty-seven in the first eight days of injection. Since the increase in *X*'s case was very slight, it appears that it was rather in an avoidance of him, than in increased combat upon his part, that his rise in status took place. Numerous instances were observed in which other males approached him as if for conflict, then hurriedly withdrew as in fear. *X*, himself, seemed to have changed. His pecks were more vigorous; in combats, he appeared to be "standing his ground" with increased assurance. When the entire period of forty-eight days was considered, *X* was found to be in third place and ranking higher than

four other birds. In the pre-injection period *X* had also shared third place with another bird but had ranked above one bird only. An examination of the data in the various injection columns shows that *X* was in second rank in the first three of these, when only the days of each individual period are considered. He failed to maintain this position in the final sixteen days of injection although at this time increased dosage was in operation. In the twenty-one day post-injection period, *X* was observed to win contacts in two cases only. His return to lowest rank was therefore inevitable. As in the female flock, a coinciding injection of a second bird may have been a complicating factor. *RW*, the other experimental individual, was vigorously engaging in many

contacts and winning an increasingly greater number each day. The attention of the flock was chiefly centered about his activities. It is problematical as to what might have been the course of *X*'s later relationship to the flock, had not *RW* so nearly monopolized the scene.

RW's injections began on the thirty-fifth day of *X*'s. *RW* had been in the lowest rank in the control period (table VI). He had engaged in numerous pecking contacts with all his flock mates but many of these were indecisive in character. In those contacts resulting in withdrawal of one or the other bird, *RW* was the winner in about one-third of the cases. A change, similar in certain respects to that in *X*'s case, occurred in the first eight days of injection. The total

TABLE VI. Order in peck-dominance in male flock of ring doves *A* as modified by injection of bird *RW* with male hormone. Double vertical lines enclose the injection periods

Series I					
Doves	8 da.	0.5 mgm.			10 da.
		8 da.	16 da.	Total	
RW:W	31:13	33:10	15:34	48:44	0:9
RW:Z	21:15	11:22	2:29	13:51	18:17
RW:X	0:0	2:1	2:18	4:19	0:8
RW:TB	23:12	15:9	0:39	15:48	0:16
RW:FD	12:0	8:6	10:15	18:21	9:18
RW:TD	8:1	6:2	7:32	13:34	7:11
W:Z	6:25	7:18	7:8	14:26	15:1
W:X	0:9	0:7	1:8	1:15	0:0
W:TB	4:12	1:33	0:16	1:49	0:0
W:FD	21:47	25:36	1:4	26:40	7:1
W:TD	12:1	3:7	2:19	5:26	2:1
Z:X	7:2	4:4	0:8	4:12	0:15
Z:TB	6:15	2:10	0:12	2:22	0:32
Z:FD	8:15	13:18	8:3	21:21	5:33
Z:TD	2:2	8:4	3:0	11:4	12:37
X:TB	6:8	3:6	1:6	4:12	2:0
X:FD	15:12	12:5	2:0	14:5	2:0
X:TD	2:0	3:0	4:0	7:0	3:0
TB:FD	2:27	1:15	6:1	7:16	19:0
TB:TD	10:0	2:1	8:0	10:1	9:0
FD:TD	18:0	2:3	7:0	9:3	4:3
Total	214:206			247:469	114:202
Rank	TD(5.5)	W(6)	W(6)	W(6)	Z(6)
in	W(5)	TD(4)	RW(5)	RW(5)	RW(5)
Flock	Z(3.5)	X,Z(2.5)	TD(4)	TD(4)	TD(4)
	X,FD,TB(2)	FD,TB,RW(2)	Z(2.5)	Z(2.5)	FD(3)
	RW(0)		ED(1.5)	FD(1.5)	TB(1)
			X,TB(1)	X,TB(1)	X,W(0)

TABLE VI (Continued)
Series II

Doves	8 da.	0.5 mgm.			17 da.
		8 da.	16 da.	Total	
RW:W	20:0	0:11	0:14	0:25	0:10
RW:Z	22:0	1:21	2:20	3:41	2:14
RW:X	1:0	0:5	0:11	0:16	0:6
RW:TB	2:1	2:19	0:12	2:31	2:9
RW:FD	9:1	3:33	14:62	17:95	65:39
RW:TD	32:0	4:20	4:34	8:54	8:17
W:Z	1:11	4:1	4:12	8:13	2:4
W:X	1:4	4:1	7:4	11:5	2:2
W:TB	0:14	0:0	0:0	0:0	0:1
W:FD	1:44	3:0	13:0	16:0	23:0
W:TD	5:33	7:0	17:11	24:11	15:5
Z:X	6:15	3:5	7:15	10:20	6:2
Z:TB	0:7	1:1	1:2	2:3	3:3
Z:FD	6:21	9:0	26:3	35:3	54:4
Z:TD	2:9	7:1	32:3	39:4	17:6
X:TB	0:0	0:1	0:0	0:1	4:0
X:FD	7:6	2:1	16:1	18:2	33:0
X:TD	4:0	4:2	23:2	27:4	14:5
TB:FD	15:0	21:0	57:8	78:8	60:8
TB:TD	14:0	4:0	2:0	6:0	12:0
FD:TD	31:5	9:3	20:15	29:18	42:34
Total	179:171			333:354	364:169
Rank in Flock	W(6) Z(5) TD(4) FD(3) X,TB(1) RW(0)	RW(6) TD(5) FD(4) Z(2.5) X(2) TB(.5) W(0)	RW(6) TD(5) FD(4) Z(2) X,W(1) TB(0)	RW(6) TD(5) FD(4) X,Z(2) W(1) TB(0)	FD,TD,RW(5) W(2.5) X,TB(1.5) Z(.5)

number of decision contacts in the flock decreased, although those in which *RW* participated increased. Unlike the slight increment in *X*'s case, *RW*'s proportion of successes rose from one-third to nearly three-fourths of the total winning combats. Non-decision encounters practically ceased. Increased vigor and effectiveness on *RW*'s part was quite comparable to that in the initial stages of *X*'s injections. Unlike *X*, *RW* showed no change in rank until the fourteenth day. He was then in fourth of six places. Four days later he was in second place and so remained until his treatment ceased. *RW* was still in this position when observations ended ten days later. After the three weeks' interim, in the next control period, he was once more subordinate to the entire flock, even to *X*.

In male flock *B*, *EB* alone was injected. This bird, one of the lowest ranking flock members, showed a similar trend to that in *X*'s and *RW*'s cases, an increasing proportion of winning contacts in the first eight days of injection (table VII). Also, as in the other males, the total number of flock contacts was reduced, during this period. No great advance in social status occurred. *EB* became dominant over two birds instead of one but was still in next to the lowest rank. In the midpoint of injection, *EB* was also at the midpoint in rank. Increased dosage was begun at this time but a slump in rank occurred in the succeeding eight days. In the last sixteen days, *EB* again rose in rank, this time into second place with *PB*. The total record for forty-eight days shows *EB* in middle rank.

TABLE VII. *Order in peck-dominance in male flock of ring doves B as modified by injection of bird EB with male hormone. Double vertical lines enclose the injection periods*

Series I

Doves	8 da.	0.25 mgm.		0.5 mgm.		Total	21 da.
		8 da.	16 da.	8 da.	16 da.		
EB:GB	19:7	10:2	17:13	20:0	19:4	66:19	39:4
EB:PB	31:13	10:4	17:12	10:0	10:11	47:27	21:1
EB:BH	0:5	0:3	7:3	5:2	4:0	16:8	14:7
EB:EH	5:0	2:2	1:6	2:0	4:5	9:13	11:4
EB:EW	5:2	2:1	1:4	1:1	1:3	5:9	8:8
EB:PH	2:8	3:12	6:44	0:9	7:8	16:73	12:14
GB:PB	3:8	6:2	9:12	7:5	10:4	32:23	11:26
GB:BH	2:4	2:3	8:11	1:3	4:9	15:26	9:20
GB:EH	2:5	8:3	2:17	0:5	0:6	10:31	1:13
GB:EW	0:8	0:4	1:4	0:0	1:3	2:11	20:19
GB:PH	0:0	3:0	6:0	0:0	2:2	11:2	9:5
PB:EH	0:0	3:2	1:8	2:2	2:3	8:15	4:8
PB:EW	1:1	0:1	1:12	0:0	2:4	3:17	9:14
PB:PH	1:11	1:6	2:7	0:2	1:6	4:21	7:5
BH:EH	1:0	3:0	15:0	2:2	1:0	21:2	3:2
BH:EW	3:0	1:0	1:1	0:0	1:1	3:2	4:2
BH:PH	1:5	1:2	2:6	0:0	0:1	3:9	2:7
EH:EW	0:11	2:7	4:16	0:5	7:9	13:37	6:15
EH:PH	1:0	0:0	0:2	0:2	0:0	0:4	4:6
EW:PH	0:1	1:4	4:15	0:2	11:18	16:39	1:20
EW:PH	3:16	0:38	4:59	0:24	2:21	6:142	12:50
Total	80:105					306:530	207:250
Rank in Flock	GB(5) EH(3.5) EW(3) PB(2.5) EB,BH(2) PH(1)	PB(4) EH(3.5) GB,BH(3) EB(2.5) EW,PH(2)	GB(5) PB(4) BH(3.5) EB(3) EH(2.5) PH(2) EW(1)	PB(4) GB,EH(3) BH(2.5) EW,EB(1.5) PH(.5)	GB(4.5) PB,EB(4) BH(3.5) EH,PH(1.5) EW(1)	PB(5) GB(4) EH,EB,BH(3) PH(2) EW(1)	GB,EH(4) EW(3.5) PB,BH(3) PH(2) EB(1.5)

Series II

Doves	8 da.	0.5 mgm.			17 da.
		8 da.	16 da.	Total	
EB:GB	8:7	25:3	59:34	84:37	63:27
EB:PB	16:7	15:9	19:28	34:37	28:8
EB:BH	1:5	5:3	14:14	19:17	14:3
EB:EH	13:9	3:9	1:18	4:27	12:17
EB:EW	4:2	7:5	4:58	11:63	20:32
EB:PH	0:3	2:9	46:42	48:51	8:28
GB:PB	12:3	20:14	28:27	48:41	13:27
GB:BH	2:2	0:12	10:33	10:45	9:30
GB:EH	5:7	1:2	2:17	3:19	3:17
GB:EW	6:5	6:4	3:22	9:26	12:52
GB:PH	4:1	1:9	23:20	24:29	11:6
PB:BH	2:1	0:3	8:5	8:8	12:6
PB:EH	5:11	1:3	1:13	2:16	5:23
PB:EW	0:2	4:0	0:17	4:17	15:40
PB:PH	3:5	1:9	23:14	24:23	8:3
BH:EH	1:1	1:0	6:8	7:8	11:13
BH:EW	0:0	3:0	0:37	3:37	10:22
BH:PH	0:4	1:3	17:29	18:32	11:24
EH:EW	0:3	2:0	1:4	3:4	11:4
EH:PH	2:13	0:2	24:43	24:45	7:19
EW:PH	1:5	1:4	33:2	34:6	3:33
Total	85:96			421:588	286:434
Rank in Flock	PB(5) EH(3.5) EW,BH(3) GB(2.5) EB(2) PH(1)	EW(6) PB(5) GB(4) EH,EB,BH(2) PH(0)	BH(4.5) GB,PH(4) EB(3.5) PB(3) EH(2) EW(0)	GB(5) BH(4.5) EB(4) PB(3.5) EH,PH(2) EW(0)	GB,BH(5) PB,EB(3) EW,PH(2) EH(1)

The cause of *EB*'s rise in status in the last sixteen days is not clear. It is quite as probable that a tendency to vacillate in flock relationships was operative as that increased dosage was responsible. With cessation of injections, *EB* reverted in twelve days to lowest rank and so remained until the close of observations. The pre-injection period in series II showed him still low in rank.

Series II. Female and Male Flocks.—The second series, undertaken as a check upon the validity of apparent modifications effected by the first, was in large part a repetition of the summer's procedure. Obviously seasonal changes were unavoidable. The location of the cages was different. Shorter periods, too, seemed advisable. In most essentials, however, the two series could be considered comparable. The flocks were the same. One bird, previously injected with testosterone propionate, from each cage was used again for the same purpose.

As has been noted, *RW* and *EB*, the experimental male birds, held practically the same social status in the original and the second series control periods. *D* was again low in rank, although not as much so as in series I.

In the second series, *D* speedily reached second rank (table II); in fact, she made this change in the first three days following injection, instead of in six as in series I. By the ninth day, *D* had subjugated *C* and, until the close, was alone in top rank. This includes seventeen days of post-injection observations. A fairly comparable but much condensed behavior development (table III) to that of series I was in evidence. The consummation was reached in slightly less than half the previous record. In the post-injection period, no such rapid return to pre-injection status was evident as in series I. An increased tendency to quiet perching and a decrease in courting contacts did take place, although the latter was observed in one case on the final day.

RW in male flock *A* attained peck dominance (table VI) over all his flock on

the fifth day of injection and retained this position to the end of the second series. This was a more rapid and more complete ascendancy than that previously exhibited. Here, however, no complications with a second experimental subject obscured results. Perhaps this accounted for the more complete dominance shown. While *RW* was still in top rank in the closing days, two other birds were then sharing it with him. On the last two days he was noticeably losing in combats on the perch which previously he had kept free of intruders.

In male flock *B*, *EB* showed no such striking changes in rank (table VII) as did *RW* in flock *A*. Nevertheless, the same ranks, which had been held in similar periods in series I, were attained in the corresponding eight and sixteen day intervals. A greater contrast was found in behavior. *EB* was more active throughout series II than in series I, continuing the activity over into the post-injection period. At the end of that interval, he was still slightly above mid-rank.

THE EFFECT OF INJECTION OF TESTOSTERONE PROPIONATE UPON THE TYPE OF DOMINANCE FOUND IN RING DOVES

An examination of the data for the birds injected with testosterone propionate shows that, in a number of cases, an apparent change in the type of dominance had occurred. In contacts with other birds, these injected individuals developed a despotic type of relationship similar to that known as a peck-right. *RW* illustrates this point. In the pre-injection period in series I (table VIII), he won twelve encounters with *TB* but lost twenty-three. In other words, *TB* was at that time peck-dominant over *RW*. In the first two weeks of injection, a similar condition persisted, so far as the total contacts are concerned. (Two weeks were used as the initial period in table VIII because it was found that the sig-

pre-injection and injection periods. Eight similar cases, in point of time and sequence of developments, occurred in pairs in which no injected birds were present. This fact supports the conclusion that consistency in dominance, which eventually approaches a peck-right, is not dependent upon injection with testosterone propionate. However, there are strong indications in the situation as a whole that treatment with this androgen causes a decided trend away from the looser peck-dominance toward the more stable peck-right type of social organization.

DISCUSSION

The data from observations in this investigation on the effects of testosterone propionate, in both series, in pre-injection, injection, and post-injection periods, show the usual alignment in hierarchies of the peck-dominant type (tables II, IV, V, VI, and VII). Moreover, the data support Riddle's assumption (Whitman, '19) that combats in ring doves in either sex probably depend upon varying degrees of maleness. In the case of both sexes, in all flocks, the same general trend is apparent so far as the experimental birds are concerned (table IX). These birds

TABLE IX. *Number of birds in each ring dove flock over which peck-dominance was held by individuals treated with male hormone. One point is allowed for complete peck-dominance; five-tenths points for shared rank*

Dove	Series I			Series II		
	Pre-injection	Injection	Post-injection	Pre-injection	Injection	Post-injection
♂ X	1.5	4.0	1.0	1.5	—	—
♂ RW	0.0	5.0	5.0	0.0	6.0	5.0
♂ EB	1.5	3.0	0.0	1.0	4.0	3.5
♀ D	0.5	5.5	4.0	1.5	6.0	6.0
♀ RH	0.5	5.5	5.5	1.5	—	—
Mean	0.8	4.6	3.1	1.1	5.3	4.8

each advanced in flock rank in a more or less marked degree and maintained the new status with considerable consistency, at least so long as injections continued.

The change in female flock position was consistently quite marked, that in males in most cases less so. Not only was a general trend characteristic in relation to rank, but also in behavior. More activity was shown in the winning contacts on the part of the experimental subjects. In females increased and livelier courting behavior of a male character developed. The observations as a whole lead to the conclusion that an elevation in social rank in ring doves is correlated with augmented aggressiveness in behavior. Apparently such behavior is characteristically male.

Ascendancy in each of the experimental birds appeared in a clearly marked degree after from five to fourteen days of injection with testosterone propionate. In the second series it developed more rapidly in two cases, *D*'s and *RW*'s, than in the first; in *EB*'s, less so. The decline toward submissiveness, following cessation of injection, was not rapid in most of the cases. *X* dropped quickly, but as has been noted, his case was complicated by *RW*'s. *EB* in flock *B* showed a similar tendency in series I but the reverse in series II. It may be in series I that the treatment in *X*'s and *EB*'s cases, in late summer, had postponed molting beyond that of their flock mates. After injection ceased and molting set in, the lowered vitality of these birds may then have operated against them, offsetting the hold-over effect of hormonal treatment on pugnacity.

Allee and co-workers ('39) found in hens that "higher position once won was retained." In ring doves, with two exceptions, the birds injected with testosterone propionate, after once attaining a higher status, maintained this rank while injections were still continuing. Consistency in the maintenance of the higher status was not as marked in these birds as in hens, although there was some approach toward such stability. As previously noted, *X* in male flock *A*, series I, held a lower rank in the last sixteen days than at any time following his initial rise. *EB*'s status in series I under-

went a temporary slump immediately following the midpoint in injection. *EB*, unlike *X*, recovered his previous status when the dosage was increased. Moreover, he improved it. It may be that as high consistency in maintenance of rank is not to be expected of birds whose social organization is peck-dominant in type as of those with a definite peck-order.

While the ring doves, during injections, showed a fixity in newly acquired status somewhat approaching that found in hens, with cessation of treatment the situation was not parallel. In the first series, as previously noted, both *X* and *EB* rather abruptly resumed a lower status. That all such doves may return to the low ranks in which they were originally observed is indicated. The data obtained in the control period for series II, thirty-nine days in two cases and fifty days in three, following cessation of treatment, showed all five experimental birds in ranks corresponding to those in the original pre-injection period. The time element seems an important one. Physiological changes probably occur. Memory, too, may play an important rôle.

The social structure of the entire flock appeared to acquire greater stability during the latter part of the injection periods. Frequently ring doves high in rank at any given time are found to be consistently so at all times. An inspection of tables II, VI, and VII will show that female *C* and males *TB* and *GB* are birds of this type. Perhaps with the advancement of an additional bird, under conditions which seem to develop stability in the bird itself, the flexibility of the group is lessened. At any rate, during a period of seventeen days, late in the first series' injection period, no change occurred in the hierarchy in male flock *A*. Each rank, too, was occupied by a single bird. This flock structure broke up only as injections of the second member, *RW*, were initiated. In male flock *B*, no change in relationship occurred after the twenty-third day, that is, during the latter half of the period of treatment. In this case, a linear flock

order, nearly as complete as in flock *A*, was observed. In only one case was there more than one bird in a rank. In that there were two. An implication of this tendency toward increased social stability, which was observed when a single bird was treated with male hormone, together with the fact that frequently birds high in rank are consistently so, may be that in birds showing the peck-dominant type of social order, the hormonal balance is less stable than in those where the peck-right is found.

That the explanation of the increased stability observed may lie in the expression of territorialism, rather than in any new development, is altogether possible. Territory is, without question, a factor in the organization of many flocks, even in highly domesticated birds such as pigeons and doves. Taylor ('32) in referring to this matter says that "when the intruder has slipped into his own place his neighbors pay no more attention to him; but if he is out and some other bird comes into place . . . a neighboring bird will drive out the invader promptly and emphatically." Even in the limited confines of the cages and in the homosexual flocks used in this investigation, there were a number of evidences of such behavior. In male flock *A* in the second series, the experimental bird appropriated one perch and usually maintained it against all others. If he left it and a second bird sought to occupy it, he sometimes ignored the fact, particularly when feeding. Certain remaining birds would chase the intruder away as if disturbed by the presence of other than the customary resident. Flock *A* did become quite strictly territorialized in the same period in which the flock structure was notably stable. Still the evidence that territorialism fully explained increase in flock stability is inconclusive. The experimental birds, with the exception of the one in flock *A* in series II, became more mobile and less confined to a particular location as injections continued.

In ring doves, behavior changes appeared, following the initiation of injection.

tions of testosterone propionate, with greater expedition than the observed modification in social status. The latter appeared in definite form in from five days to two weeks. In males, a decrease in the number of observed pecking contacts appeared to follow the marked change from submissive to aggressive behavior on the part of the experimental bird in the flock. In females the initial appearance of the stages of the gamut of male courting conduct preceded in each case the first observable modifications in social status. *D*'s first bowing-coo preceded by one day her first advance in rank. *RH* began frequently and vigorously performing this same act on the second day, although observed in it but once before treatment. The fact that behavior changes preceded changes in social position, agrees with the observations in flocks of hens (Allee and others, '39).

The data from the second series of injections show no significant differences from those obtained in the first series. It appears that the same birds, in relation to the same flocks, after an extended recess in experimental treatment, react very similarly, both in relation to the social hierarchy and in individual behavior. The female response in both behavior and ascendancy was more accented than that of the males, but both females and males reacted more readily in the second than in the original series. This increment in efficiency suggests that some holdover from the first series, it may be both psychological and physiological, is in operation. That results in both series show similarity and that they parallel results in flocks of other birds as widely different as chickens and canaries, appears to support the theory that male sex hormone is an important factor in flock organization of birds.

Cases in which a peck-right form of relationship develops between members of a ring dove pair are not uncommon. The data in series I and series II (Table VIII) indicate that such developments may appear in both injected and uninjected indi-

viduals in the same intervals of time. Eight cases, involving reversal following injection, developed into a situation comparable to a peck-right. A single case of a similar type appeared among the uninjected birds. Apparently in the remainder of all cases in which a shift in balance of power was taking place, peck-dominance prevailed. Five cases, in which no reversal occurred, but in which the injected bird was the dominant one, developed, or maintained throughout, a peck-right type of dominance. Ten such cases were recorded for doves which were not injected. Evidently such cases are far from unique. On the other hand, two observations support the conclusion that the frequency of development of the peck-right type of dominance is greater in injected birds than in untreated ones. In the first place, a shift in dominance in untreated birds rarely resulted in the peck-right condition. In treated birds, a number of such developments followed the beginning of injection. In the second place, a greater percentage of possible contact pairs, in which one bird was injected, developed a peck-right type of dominance than was the case in the others. The possible contact pairs of the injected individuals were forty-eight (five birds in series I and three in series II, with six possible contact pairings each). This is in contrast with 170 possible pairings (204, if injected birds are included) with uninjected birds. The records show nine cases, or 18.7 per cent, of the possible contact pairings in injected birds, with a peck-right type of dominance following two weeks of injection and persisting so long as injections continued. In possible pairings, of uninjected birds, 6.4 per cent show a similar sequence of development. The evidence suggests that injection of ring doves with testosterone propionate is accompanied by an increase in development of a peck-right type of dominance as contrasted with the usual peck-dominant social order found in these birds.

SUMMARY

1. Administration of testosterone propionate to a low ranking, submissive member of a caged flock of ring doves of either sex, in all cases, resulted in advance in social status and, in all but two partial exceptions, in a maintenance of this position throughout an extended period of injection.

2. Repetition of the procedure, after an interval of weeks, using the same flocks and three of the same individuals for the experimental treatment, produced results paralleling those of the original series.

3. Behavior changes occurred in the injected individuals of both sexes. Both showed increase in vigor and augmented effectiveness in combat. Male sex behavior characteristics in a cumulative, progressive series appeared in hitherto passive females.

4. Peck-dominance rather than peck-right is the rule in caged flocks of ring doves. Occasional cases of dominance, similar to a peck-right, appear in dove flocks. The injection of flock members with testosterone propionate is followed by an increased development of a peck-right type of dominance, not explained by the ordinary sequence of events among uninjected flock members.

5. A modification in the social hierarchy of the ring dove flock can be induced by treatment of one of its members with an androgen. The results seem to support the conclusion that, as in chickens and canaries, one approach has been found to a better understanding of the physiological processes which underlie the social organization in birds.

6. Treatment with male hormone augmented aggressiveness in both female and male ring doves. This investigation, therefore, experimentally confirms Riddle's postulation, made two decades ago, that combats in either sex of these birds are probably due to varying degrees of maleness.

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